HIGH PRECISION STEREO COMPARATOR STUDY

MONTHLY NARRATIVE REPORT

For Period Ending August 6, 1965

1. Current Status of Work

During the reporting period a project group was formed consisting of optical, mechanical and electronic engineers and work is now proceeding in four general areas: Optical Design, Mechanical Design, Correlation Techniques, and Metering Techniques.

A. Optical

A review of the optical system requirements has been started, beginning with the illumination requirements. A recheck of this calculation has confirmed the estimates of the brightness requirement contained in the proposal. Because of numerous advantages to be gained by using a single optical system for both the correlator and the visual observation system, a study was conducted of the practicality of using a flying spot scanner as the input to both systems. In this technique there is the additional advantage that the operator's console and the two film stages can be physically independent of each other, since the presentation to the operator would be on two CRT's. Unfortunately, the very high resolution requirements of the visual observation system were found to rule out this approach. Although the resolution might be achievable in the scanning system itself, the scanning rate would have to be so slow as to be unacceptable to the operator, and extreme image smearing would occur for even slow film motion.

B. Mechanical

Work has been started on the general configuration problem, with particular attention being given to ease of access for loading and unloading, and convenience of viewing the overall frame area. At present the project group is in accord with the specification requirement that the film transport mechanism be isolated from the X-Y measurement stage. A configuration is being considered in which the film supply and take-up spools would track one axis of the measurement stage, and guides would be provided so that the entire transport could track the second axis. These same guides would then provide for withdrawal of the transport mechanism for loading and unloading.

Work on the design of the X-Y measurement stage itself has been postponed pending the completion of a newly designed air bearing system having a (10" x 10") travel range. While it is recognized

that this range does not meet the requirements of the High Precision Stereo Comparator, in other respects (straightness of travel, orthogonality, etc.) the specifications set for the 10" x 10" stage, developed on a company-sponsored program, are compatible with those of the Stereo Comparator. It is felt that the experience gained in evaluating the performance of the 10" x 10" stage will therefore be of direct benefit to the Stereo Comparator, since it will establish the validity of the design principles used.

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During the reporting period, a visit was made to the [redacted] STATINTL facility at [redacted] to discuss STATINTL problems associated with precision measuring stages. Measurements were made by [redacted] personnel on the performance of the [redacted] Number 5 Measuring Machine. Over an 18 inch range the machine exhibited straightness of travel within ± .3 microns, although the guaranteed value is ± 1 micron. This, however, is attributed to the use of sliding bearings, which would make the desired least increment of motion extremely difficult to achieve. Nevertheless, the project group does not feel justified in arbitrarily excluding all but air bearing designs, and continuing thought will be given to the capabilities of such companies as [redacted] STATINTL

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C. Correlation

Three separate correlation techniques will be evaluated during the study program. The first uses an optical matching technique. In order to implement it in a form suitable for the Stereo Comparator, it is necessary to scan one transparency and present it on the face of a CRT suitably positioned with respect to the second transparency. The correlation error signal then consists of the distribution of light in a plane determined by the geometrical configuration of the two images. In order to separate the correlation signal from the background noise experience has shown that it is necessary to oscillate the images about their correct rotary alignment and then synchronously detect the resulting signal variation. This technique relies on the fact that the correlation signal is typically much more sensitive to rotary alignment than the background noise is.

During the reporting period a breadboard was assembled to test the basic system. Available equipment was used in the interest of speed, and therefore conditions were not optimum. For example, a low resolution, rather non-linear scanner was used, and the CRT phosphor was not well matched to the photo-sensor response curve. Theta rotation was accomplished manually and DC readings of the photo-sensor output were taken to predict the response which an automated system would produce. Signals which appeared to be

usable were obtained with identical artificial imagery and with identical aerial photography. The accuracy with which the null signal reflects the correlation position has not yet been determined, nor have tests been conducted on stereo-pairs.

The other two types of correlators are similar to each other in that each uses a flying spot scanner to extract information from the imagery. They differ in the method of processing the video signals to obtain the correlation signal. One method, called the electronic analog correlator, operates on the frequency components of the analog video signal in order to establish the phase relationships between corresponding components of the two video channels, which are indicative of positional displacements between the two transparencies. The second method, called the electronic digital correlator, quantizes the video signals into pulse trains which are then cross-compared with several permutations of time delays between the two channels. In this system the time delay which provides the best match is indicative of the relative displacement of the two transparencies.

Breadboarding of the digital correlator has been under way for several months as part of another program. It is expected that the results of this effort will be available for use in the Stereo Comparator design study.

During the reporting period an analysis was begun on the theory of the electronic analog correlator. This analysis is expected to lay the groundwork for an interpretation of the experimental results to be obtained later in the program, and to serve as a basis for logical changes in the breadboard as the quality of the results becomes apparent. Design and fabrication of breadboard circuits will be started in the next reporting period.

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A survey of available metering systems has been started. The [redacted] has been contacted for information about the Linear Phase Resolver and a trip is planned to inspect their prototype and obtain detailed information about the electronic system. Results of an evaluation of the [redacted] system, STATINTL to be made on [redacted] premises on another program, will be available for comparison.

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A configuration for a laser interferometer is being developed and an analysis has been started to determine the magnitude of errors resulting from irregularity of table motion.

2. Problem Areas

The major technical problems are those inherent in the performance required of the comparator, and are generally defined by the division of the study program as described above. In addition, several specific questions have arisen which have been submitted via telephone to the contracting office. These are:

A. The specification requirement (Section 5.2.7) that the illumination system have a color temperature above 3400°K at any intensity level appears incompatible with standard practice, adds to the complexity of the equipment, and may increase the heat problem. The implication of this should be discussed at the next personal visit.

B. The wording of Section 5.4 (Film Measurement System) raises a question regarding the accuracy specification. If this is interpreted as including the effects of ambient environment on the photographic film itself, then the humidity variations permitted by the ambient environment specification could cause errors greatly in excess of those permitted in Paragraph 5.4.1. Compensation for this effect, if it could be accomplished at all without lengthy film preparation, would be a very great problem. The practical solution seems to be to interpret this section as a specification of the performance of the comparator itself, independent of the characteristics of the input material.

C. There is no question about the operational necessity of providing the operator with an overall view of the entire format area (Section 3) and a means of seeing which portion of a frame is within the field of view of the optical system. However, the practicality of doing this in the suggested way, by direct observation of the measuring area, is very doubtful because of the requirement for full stage illumination, the number of frame and optical system obstructions, and the probable distance between the operator and the measuring stages. For this reason, consideration will be given to electronic or optical scanning systems which will permit transmitting an image of the entire stage area to a convenient position in front of the operator, possibly with the final display presented on a high resolution CRT.

3. Projected Work for Next Reporting Period

A. Mechanical: Configuration studies will be continued with particular emphasis on the interface between the film transports and X-Y measurement stages. An analysis will be started on the design of the X-Y stage itself.

B. Optical System: The analysis of the resolution and illumination requirements of the optical system will be continued. Because of the high probability that a flying spot scanner will be used to provide information to the correlator, the study will examine the various techniques for combining the visual optical system with the scanning system. In particular, a study of the distribution of light energy between the two systems and the most advantageous placement of image rotation, zoom, and anamorphic elements will be started.

C. Correlation: Work on the optical correlator will be continued and it is planned to evaluate the effectiveness of this system in cross-correlating on stereo-pairs. Equipment will be procured to enhance the effectiveness of the present breadboard. This will consist principally of scanners with higher resolution, better linearity, and better match to the photo-sensor characteristics.

Breadboarding of the electronic analog correlator circuits will be started.

D. Metering System: It is expected that an inspection of the Phase Resolver System will be made during the next reporting period. A configuration for a laser interferometer will be developed and procurement started for the material needed for breadboarding.

4. Expenditures

Manhours:
Material:
Total Cost: [redacted]

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5. Verbal Commitments and Agreements

In the first meeting (July 23, 1965) between the Contracting Office and Contractor, three points were established which had not previously been apparent.

A. The film transport design must take into account the possible use of very thin film bases. These film bases may be as thin as 1.5 mils.

B. In the contemplated use, speed of loading and unloading is of great importance. The typical operation consists of observations made on single frames of roll film or a single film chip.

C. The integration of an effective correlation system is vital to the success of the Comparator. Correlation is desired between any combination of image pairs, including difference in scale, rotation, type of photography, density, etc., even when the parameters of the photography are initially unknown.